DEPARTMENT OF THE ARMY
Corps of Engineers, Northwestern Division
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CENWD-ET-E
Regulation
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Engineering and Design
PRESSURIZED WATER LINES IN EXISTING DAM EMBANKMENTS

History. This issue is a new regulation for the Northwestern Division (NWD).

Summary. This regulation establishes policy on installation and testing of pressurized water lines in existing dam embankments at Corps of Engineers projects.

1. PURPOSE. This regulation establishes policy, procedures, and responsibilities of the district's Dam Safety Officer and Dam Safety Committee on the installation and testing of pressurized water lines in existing dam embankments.

2. APPLICABILITY. This regulation is applicable to all districts in the Northwestern Division.

3. REFERENCES.

a. Required publications:

(1) EM 1110-2-4205, Engineering and Design, Hydroelectric Power Plants, Mechanical Design. Cited in paragraph 9.

(2) EM 1110-2-2902, Conduits, Culverts and Pipes. Cited in paragraph 8.

(3) TM 5-813-5, Water Supply and Distribution Systems. Cited in paragraph 8.

b. Related publications:

(1) ER 1110-1-12, USACE Engineering and Construction Quality Management

(2) ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures.

(3) ER 1110-2-109, Hydroelectric Design Center.

(4) ER 1110-2-1156, Dam Safety – Organization, Responsibilities, and Activities.

4. RESPONSIBILITIES.

a. The district's Dam Safety Officer is responsible for insuring that the district's Dam Safety Committee has reviewed and approved the installation of all new pressurized water lines and the testing of all existing lines in accordance with this policy.

b. The district's Dam Safety Committee is responsible for the approval of the design and installation of new pressurized water lines, and the testing of existing lines in accordance with this policy.

5. POLICY. This policy is applicable to new and replacement buried pressurized water lines or siphons in, and adjacent to, existing earth dam embankments and appurtenant structures, including spillways, intakes and outlet works at Corps projects. The policy also covers the connection of water lines to existing penstocks, surge tanks and power plant piping systems and associated pumping facilities.

6. GENERAL. It is recommended that all pressurized pipes carrying liquid be located outside of the earth dam embankments, abutments and adjacent control systems for dam underseepage. There is concern that leakage from the pipeline could cause embankment slope damage from localized instability or erosion of embankment materials. It is possible that leakage could also be interpreted to be a dam safety problem or inverse, more important, a serious potential dam safety problem could be misinterpreted as pipeline leakage. Construction of pumping facilities and/or hydraulic connections to existing dam structures could also generate serious structural or flooding problems. Pipelines shall not be allowed to penetrate earth embankments below the freeboard zone.

7. ENGINEERING STUDY. An engineering study to support the request for a pipeline installation must be submitted for approval to the district's Dam Safety Committee. The study, as a minimum, should show the proposed pipeline size, routing, connections, location of existing utilities, dam instrumentation, relief wells, other drainage systems, and areas of geotechnical concern. The study should also show adequate capability for construction and maintenance of the pipeline and/or pumping facilities. The study should contain a brief project management and quality control plan. Approved study requests should be identified in the districts biannual Dam Safety Committee meeting minutes.

8. PIPES IN THE EMBANKMENT. Water lines in earth embankments must be designed so that the lines and joints can accommodate movement in the embankment and foundation from long term settlement, slides or seismic activities in the area. The embedment of lines shall be designed so that any leakage from the lines will be readily detected before affecting piezometer readings, relief well or other drainage system discharges. Pipelines located in areas of

geotechnical concern, where leakage could cause significant soil erosion, piping or saturating of the soil, should be avoided. These areas, of geotechnical concern, will normally include downstream toe areas, slopes and abutments. Design of pressure pipes installed in these areas shall include features such as a pipe within a pipe, seepage collector systems or other systems that allow the source of seepage to be readily determined. Pipelines in these areas shall be designed with a minimum factor of safety of 4 based on the maximum hydraulic transient pressure, a minimum life of 50 years, and shall follow the guidance in EM 1110-2-2902, TM 5-813-5, and American Water Works Association (AWWA) Standards, except as modified herein. Pipelines outside the areas of geotechnical concern shall follow the guidance in TM 5-813-5 and AWWA Standards. Pipeline water velocity and design pressure shall not exceed the manufacturer's published recommendations or AWWA Standards as applicable. All backfill materials shall be suitable and adequately compacted to a density approximating that of the adjacent undisturbed embankment or foundation materials. Concrete markers shall be provided on the ground surface to clearly indicate the location and depth of the buried pipeline. Concrete markers shall be located at least every 500 feet and/or change in direction of the pipeline. Where plastic piping is used, metallic tape should be installed above the pipeline.

9. PIPE CONNECTIONS. Pipe connections to existing penstocks, surge tanks, and risers shall only be made by cutting and welding if no other alternate connections are possible to other piping systems within the powerhouse or other structures. A thorough engineering analysis shall be made in these situations in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Pipeline connections shall contain a motor-operated, rising-stem, gate valve at the point of connection. This gate valve shall provide for system isolation and emergency closure within one minute or less. When multiple connections are being made to a water supply, or water is being pumped to a higher elevation, a positive means of backflow prevention into each point of connection shall be made. Piping to be installed within power plants or other structures shall be designed for a minimum factor of safety of 4 based on the maximum hydraulic transient pressure, and shall be in accordance with EM 1110-2-4205, Chapter 17, Piping. In general, the referenced EM indicates that water velocities in the range of 2.4-3.7 m/s (8-12 fps) are reasonable, but there is often good justification for higher or lower, velocities. The maximum of 3.7 m/s (12 fps), however, should not be exceeded under any operational scenario unless it can be demonstrated that cavitation, erosion and noise, or loss of the protective coatings at the point of connections will not occur. Lower water velocities, based on hydraulic transient analysis, may be required in order to satisfy the factor of safety required for the piping system. All piping shall be protected from freezing.

10. HYDRAULIC TRANSIENT ANALYSIS. Computerized hydraulic transient analysis shall be performed to determine the maximum surge pressures on all pressurized water lines. These hydraulic transient analyses shall be based on maximum operating pool elevations and/or pumping systems. Hydraulic transient analysis shall include any surge pressures from turbine load

acceptance or rejections at the points of connection. The analyses shall include all components and operational scenarios in the length of pipe from the point of connection to the point of discharge. Studies to determine the maximum hydraulic transient pressures shall be in concurrence with the district's engineering division and/or the Hydroelectric Design Center. The design of the piping system, including piping materials, fittings, valves, restraints and thrust blocks, etc., shall be based on the maximum hydraulic transient pressures. Bypass valves, air vents, etc., shall be provided to minimize waterhammer during filling or draining of the piping system.

11. CORROSION PROTECTION. Buried metallic lines and casing pipes for secondary containment shall be provided with cathodic protection. Routing of these lines should avoid areas adjacent to the switchyard and power plant grounding system. Induced currents shall be investigated when metallic lines are buried in the vicinity of high voltage transmission lines. Appropriate mitigation procedures should be included in the design to minimize the effects of these stray currents. When cathodic protection systems are provided, they shall be designed by a corrosion engineer for a minimum life of 50 years. Adequate provisions shall be made for inhibiting interior pipe corrosion including limiting velocities to prevent corrosion from erosion and cavitation. Provisions shall also be made for isolation of pipe sections for testing and inspection.

12. PUMPING FACILITIES. Structures required for pumping water to elevations higher than pool elevation shall be located a sufficient distance downstream to avoid interference with dam monitoring and evaluation functions, or any future investigations or activities required to ensure the continual safety of the projects and related operation and maintenance activities. New structures shall not be located on the embankment, abutments, or toe of the dam. If pumping facilities cannot be physically located downstream, consideration should be given to locating these facilities in an existing structure where they can be located away from normal operation and maintenance activities.

13. DESIGN APPROVAL. Concept designs, hydraulic transient analysis, design analysis, and plans and specifications for pressurized water lines, piping connections, and new pumping structures being considered for installation at dam projects shall be reviewed by all appropriate disciplines in the district office. The services of the Hydroelectric Design Center should be utilized where the specific design capability does not reside in the district office. Concept designs must be approved by the district's Dam Safety Committee before proceeding with design. In-house and AE designs shall have a written quality control/quality assurance plan which includes independent technical review. Designs being performed by other agencies shall be reviewed by the district. As-built drawings shall be furnished at the completion of the construction contract. Appropriate features from these drawings shall be incorporated into the project's dam surveillance and contingency plans. When agencies other than the Corps are involved, a proposed

Memorandum of Agreement (MOA) must be developed that identifies ownership, responsibilities, liabilities, operation, maintenance and repair, testing requirements, and abandonment of the system. This MOA shall also state the conditions under which the water supply may be interrupted, such as pipeline leakage or during total power plant outages. For the purpose of dam safety and project operation and maintenance safety, the MOA shall state that the Corps shall have access to and maintain control of all isolation valves at water supply connections. Approval of the final design, plans and specifications, methods of construction, MOA's etc., shall be the responsibility of the district's Dam Safety Committee.

14. TESTING OF PRESSURIZED WATER LINES. All new pressurized water lines shall be subjected to hydrostatic and leakage testing prior to being placed into service. Hydrostatic tests on new lines shall be performed at 1.5 times the maximum hydraulic transient pressure, with a minimum pressure of 689kpa (100 psi). Leakage from embedded pipelines shall not exceed the lessor of the maximum values established by AWWA or by the district's geotechnical engineers. All pressurized water lines, embedded in earth embankments, abutments, etc., and areas of geotechnical concern, shall be tested for leakage at intervals not exceeding 25 years. Existing piping 25 years and older shall be scheduled for testing within 5 years. Where leakage testing of existing piping is impractical, visual or video inspection of the interior of the pipeline should be accomplished. Embedded pipelines in areas where there has been significant settlement, active slides or seismic activity shall be tested at more frequent intervals. These testing intervals shall be determined by the district's geotechnical engineers. Leaks found in pipelines shall immediately be reported to the district's geotechnical engineers and Dam Safety Committee. The decisions to take these pipelines out of service, until repaired, shall be made by the district's geotechnical engineers and approved by the Dam Safety Committee.

FOR THE COMMANDER:

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